Topic 14 Coordination and Response

14.1 Coordination and Response

Coordination is the process by which an organism detects and responds to changes in its internal or external environment. This is regulated by the **nervous system** and the **hormonal (endocrine) system**.

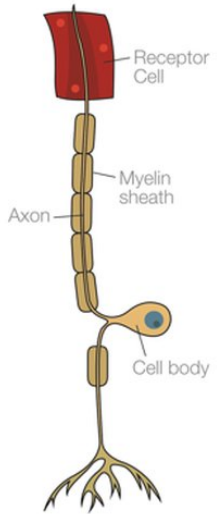
The Nervous System

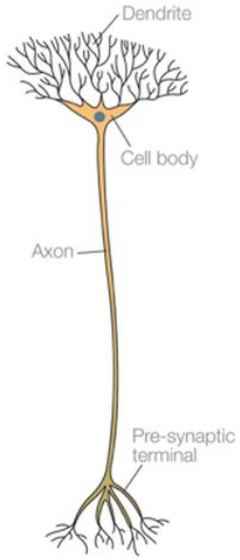
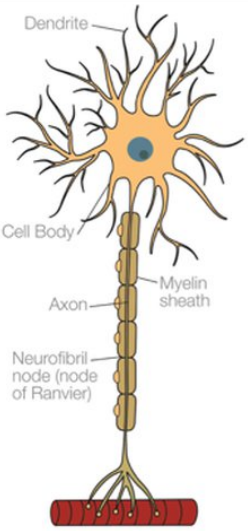
The nervous system is an organ system that coordinates and regulates body functions using **electrical impulses** that travel along specialized cells called **neurones**.

Structure of the Mammalian Nervous System: The mammalian nervous system is divided into two main parts:

1. **Central Nervous System (CNS):** Consists of the **brain** and the **spinal cord**. It is the processing center for information.
2. **Peripheral Nervous System (PNS):** Consists of all the **nerves** that lie outside the CNS. It connects the CNS to the rest of the body.

Types of Neurones: The nervous system uses three types of neurones to transmit information:

Neurone Type	Function	Direction of Impulse	Shape
Sensory Neurone	Transmits impulses from a **receptor** (sense organ) to the **CNS**.	Towards the CNS	

Neurone Type	Function	Direction of Impulse	Shape
Relay Neurone	Connects sensory neurones to motor neurones, found entirely within the **CNS** (brain and spinal cord).	Within the CNS	
Motor Neurone	Transmits impulses from the **CNS** to an **effector** (muscle or gland).	Away from the CNS to an effector	

The Reflex Arc and Reflex Action

A **reflex action** is an **automatic, rapid, and involuntary response** to a stimulus. It is coordinated by the reflex arc, which ensures a quick response to protect the body from harm.

The Reflex Arc: The pathway of the nerve impulse in a reflex action is known as the reflex arc:
Stimulus → Receptor → Sensory Neurone → Relay Neurone (in CNS) → Motor Neurone → Effector → Response

The Synapse

A **synapse** is a microscopic junction between two neurones.

Structure of a Synapse:

- **Vesicles:** Located in the end of the first neurone (presynaptic knob), containing **neurotransmitter molecules**.
- **Synaptic Gap (Cleft):** The small gap between the two neurones.
- **Receptor Proteins:** Located on the membrane of the second neurone (postsynaptic membrane).

Events at a Synapse:

3 An electrical impulse arrives at the end of the first neurone.
4 The impulse triggers the release of **neurotransmitter molecules** from the vesicles into the synaptic gap.
5 The neurotransmitter molecules **diffuse** across the gap.
6 They bind to the **receptor proteins** on the membrane of the next neurone.
7 The binding generates a new electrical impulse in the second neurone.

Direction of Impulse: Synapses ensure that impulses travel in **one direction only** because the neurotransmitter is only stored in the presynaptic neurone and the receptors are only on the postsynaptic neurone.

14.2 Sense Organs

Sense organs are groups of receptor cells that respond to specific **stimuli** (e.g., light, sound, touch, temperature, chemicals) and convert the energy of the stimulus into an electrical impulse.

The Eye

The eye is the sense organ for light.

Part	Function
Cornea	Transparent outer layer at the front of the eye; **refracts (bends) light** to focus it.
Iris	Coloured part of the eye; controls the **amount of light entering the eye** by changing the size of the pupil.
Pupil	The hole in the centre of the iris through which light passes.
Lens	Transparent, biconvex structure; changes shape to **fine-tune the focus** of light onto the retina.
Retina	Light-sensitive layer at the back of the eye; contains the **light receptor cells** (rods and cones).
Optic Nerve	Carries electrical impulses from the retina to the **brain**.
Blind Spot	Point where the optic nerve leaves the eye; contains **no receptor cells**.
Fovea (Yellow Spot)	Small area of the retina directly opposite the lens; contains the **highest concentration of cones** and is responsible for sharp, detailed colour vision.

Light Receptor Cells (Rods and Cones):

- **Rods:** Responsible for **night vision** (high sensitivity) but cannot distinguish colours.
- **Cones:** Responsible for **colour vision** (low sensitivity, requires bright light). There are three types, each sensitive to a different wavelength (red, green, or blue).

The Pupil Reflex (Response to Light Intensity): The pupil reflex is an involuntary action that protects the retina from damage and helps the eye adjust to different light levels. It involves the **antagonistic action** of two sets of muscles in the iris:

- **In Bright Light: Circular muscles** contract, **radial muscles** relax → **Pupil constricts** (gets smaller).
- **In Dim Light: Circular muscles** relax, **radial muscles** contract → **Pupil dilates** (gets larger).

Accommodation (Focusing): Accommodation is the process of changing the shape of the lens to focus light from objects at different distances onto the retina.

Action	Ciliary Muscles	Suspensory Ligaments	Lens Shape	Refraction (Light Bending)
Viewing Distant Object	Relax	Taut (pulled tight)	Thin and less convex	Less refraction (less light bending)
Viewing Near Object	Contract	Slack (loose)	Thick and more convex	More refraction (more light bending)

14.3 Hormones

Hormone Definition: A **hormone** is a **chemical substance** produced by an **endocrine gland** and carried by the **blood** to a specific **target organ** or organs, where it alters the activity of that organ.

Endocrine Glands and Hormones:

Endocrine Gland	Hormone	Function
Adrenal Glands	**Adrenaline**	Prepares the body for **'fight or flight'** by increasing heart rate, breathing rate, and pupil diameter; increases blood glucose concentration.
Pancreas	**Insulin**	**Decreases** blood glucose concentration by converting glucose to glycogen in the liver and increasing glucose uptake by cells.
Pancreas	**Glucagon**	**Increases** blood glucose concentration by converting glycogen back to glucose in the liver.
Testes	**Testosterone**	Male secondary sexual characteristics.
Ovaries	**Oestrogen**	Female secondary sexual characteristics and control of the menstrual cycle.

Adrenaline and 'Fight or Flight': Adrenaline is secreted rapidly in situations of danger or stress. Its effects prepare the body for immediate action:

- **Increased heart rate and breathing rate:** To supply more oxygen and glucose to the muscles.
- **Increased blood glucose concentration:** By stimulating the liver to convert glycogen to glucose.
- **Pupil dilation:** To allow more light in for better vision.

Comparison of Nervous and Hormonal Control:

Feature	Nervous Control	Hormonal Control
Nature of Signal	Electrical impulses along neurones.	Chemical substances (hormones) in the blood.
Speed of Action	**Fast** (milliseconds).	**Slow** (seconds to days).
Duration of Action	**Short-lived** (temporary).	**Long-lasting** (more permanent).
Area of Effect	Localized (specific nerves/muscles).	Widespread (affects many target organs).

14.4 Homeostasis

Homeostasis is the maintenance of a **constant internal environment** in the body, such as body temperature and blood glucose concentration.

Control of Blood Glucose Concentration

Blood glucose concentration is controlled by the liver and the hormones **insulin** and **glucagon**, secreted by the pancreas.

- **When blood glucose is too high (e.g., after a meal):**
  - The pancreas secretes **insulin**.
  - Insulin causes the **liver** to convert glucose into **glycogen** for storage.
  - Insulin also increases the rate at which body cells take up glucose (respiration).
  - Result: Blood glucose concentration **decreases**.
- **When blood glucose is too low (e.g., after exercise):**
  - The pancreas secretes **glucagon**.
  - Glucagon causes the **liver** to convert stored **glycogen** back into **glucose**.
  - Result: Blood glucose concentration **increases**.

Negative Feedback: Homeostasis relies on **negative feedback**, a mechanism that reverses a change to bring the internal environment back to a **set point** (normal level). For example, if blood glucose rises above the set point, the body responds to lower it. If it falls below the set point, the body responds to raise it.

Type 1 Diabetes: Type 1 diabetes is a condition where the pancreas fails to produce enough insulin.

- **Treatment: Insulin injections** (or pump) to replace the missing hormone, and careful monitoring of blood glucose levels and diet.

Temperature Regulation

Body temperature is maintained at a set point (around 37 °C) by the brain, involving the skin.

Mechanism	Response to High Temperature (Cooling)	Response to Low Temperature (Warming)
Sweating	**Sweat glands** secrete sweat. Evaporation of sweat from the skin surface removes heat.	Sweating stops.
Blood Flow to Skin	**Vasodilation:** Arterioles supplying skin capillaries widen, increasing blood flow near the surface to lose heat by radiation. Skin appears red/flushed.	**Vasoconstriction:** Arterioles narrow, reducing blood flow near the surface to conserve heat. Skin appears pale.
Hair	Erector muscles relax; hairs lie flat (no effect on humans).	**Erector muscles** contract; hairs stand up, trapping a layer of insulating air (less effective in humans).
Shivering	Stops.	**Shivering** (rapid muscle contractions) starts to generate heat through increased respiration.
Insulation	-	**Fatty tissue** under the skin acts as an insulator.

14.5 Tropic Responses

Tropic Responses are growth movements of a plant in response to a directional stimulus.

Tropism	Stimulus	Response	Example
Phototropism	Light	Growth **towards** (positive) or **away** (negative) from light.	Shoots are **positively phototropic** (grow towards light).
Gravitropism	Gravity	Growth **towards** (positive) or **away** (negative) from gravity.	Roots are **positively gravitropic** (grow downwards). Shoots are **negatively gravitropic** (grow upwards).

Chemical Control of Plant Growth (Auxin)

Phototropism and gravitropism are examples of **chemical control** of plant growth, primarily by the hormone **auxin**.

Role of Auxin in Shoot Growth:

1. **Auxin production:** Auxin is made in the **shoot tip** (apex).
2. **Diffusion:** It diffuses downwards through the plant.
3. **Unequal Distribution:**
    - **In response to light (Phototropism):** Auxin moves to the shaded side of the shoot.
    - **In response to gravity (Gravitropism):** Auxin moves to the lower side of a horizontal shoot.
4. **Stimulation:** Auxin **stimulates cell elongation** (growth).
    - In phototropism, the shaded side has more auxin, so it grows faster, causing the shoot to bend towards the light.
    - In gravitropism, the lower side has more auxin, so it grows faster, causing the shoot to bend upwards (against gravity).